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Title:	Robust Fault Location in Power Grids through Graph Learning at Low Label Rates
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Robust Fault Location in Power Grids through Graph Learning at Low Label Rates

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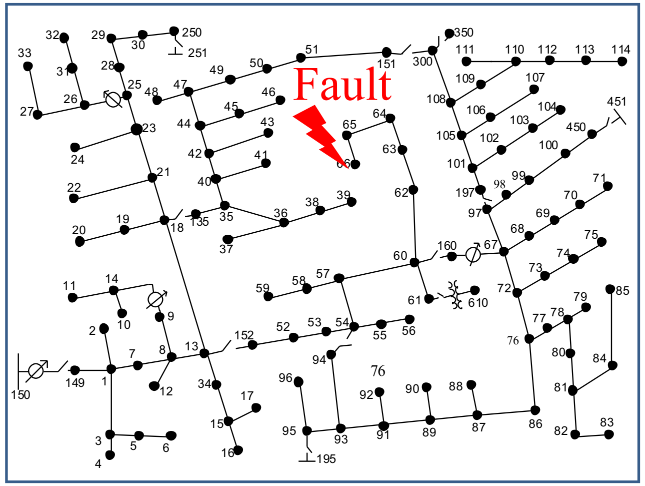
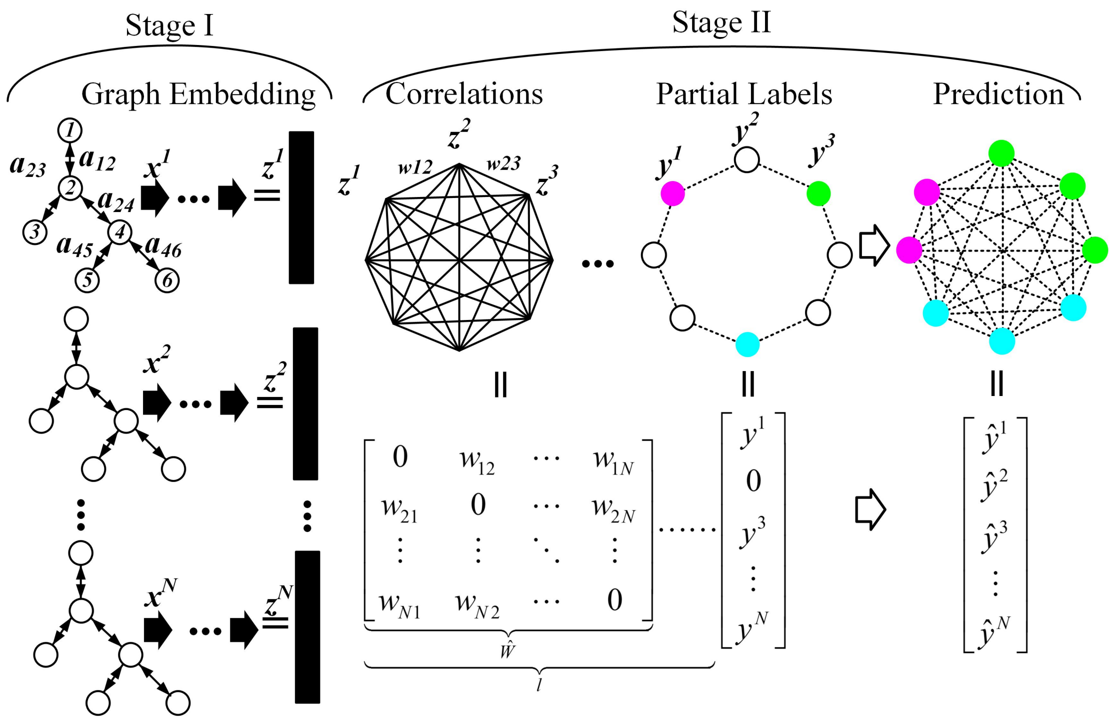


THE PROBLEM

Locating the faulty node in power grids becomes challenging when historical data are not well labeled, power systems are unobservable, and power has dramatic variations due to renewable energies, such as wind and solar power.

APPLICATION

- **Independent System Operator (ISO):** want to augment the power grids resilience by efficient fault location to avoid blackouts;
- **Utility & ISO**: obtain more accurate topology information to compute power flow, which saves significant economic loss;
- **Residents:** have less suffering due to power outages if faults are identified and cleared timely;
- **Utility companies:** are eager to utilize fully the large amounts of data measured for decades.



THE SOLUTION

- ✓ Learn embedding $z^i, i = 1, \dots N$ via unsupervised graph networks (UGN) to reveal the **local structure of power networks**;
- ✓ Predict unseen faulty locations through a **graph deep learning model** with the correlations W between known and unknown faults and the scarce labels;
- ✓ The constructed UGN is **robust** to the topology change, load variations, and faulty types, and the correlations between datasets reduce the need for labels;
- ✓ Validate in the IEEE benchmark testing feeders and compare it with the state of arts **in various situations**.

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BENEFITS

Flexible: Adapt to unknown topology changes, dramatic load variations, and noise.

Efficient: Locate a fault within millisecond with streaming datasets.

Cheap: Reduce the cost of labeling datasets and installing sensors.

Interpretable: Obey the geometry structure and physical relations.

OUR COMPETIVE ADVANTAGE

- **Conventional methods**: require a sufficient number of expensive labels, ignore the structure of datasets, or not robust to load variations and topology changes.
- **Our approach:** automatically learns from the structured graph data and outputs physically interpretable results at low label rates.
- Depending on data's intrinsic geometry structures, the proposed method is robust to topology changes and various fault types.
- Trained by tens of thousands of datasets, the learned model can tolerate the dramatic load variations due to the distributed energy resources (DER).

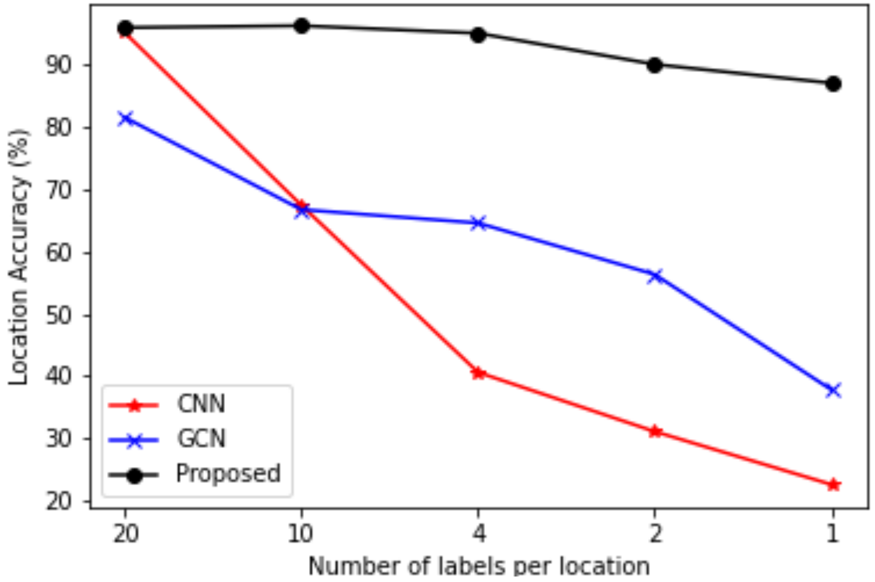

FIGURE: LOCATION ACCURACY COMPARISON WHEN LABEL RATES ARE LOW

Time Schedule

2021		2022		2023		2024	
1-6	7-12	1-6	7-12	1-6	7-12	1-6	7-12

Graph-based Deep Learning Monitoring Framework

Theoretical Analysis and Demo Demonstration

Interface Completion and Function Expansion for Wide Users

Publish as Open-Source or Commercialized Product

TECHNOLOGY READINESS LEVEL AND IP

TRL 3: The proposed approach is validated in the 123-node IEEE benchmark testing feeder, outperforming current works with significant margins. The robustness is theoretically feasible, and more complete testing and comparison are in progress.